

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Currently Amended) A method of determining production rates in a well, comprising:
 - 1 determining a model of temperature as a function of zonal flow rates in the well;
 - 2 measuring temperatures at a plurality of locations in the well; and
 - 3 inverting, by a computer, the measured temperatures by applying the model to
 - 4 determine an allocation of production rates from different producing zones in the well,
 - 5 wherein the inverting comprises using an optimization algorithm that solves an
 - 6 optimization problem for calculating the production rates, where the optimization
 - 7 problem minimizes an error between the measured temperatures and corresponding
 - 8 temperatures calculated by the model.
- 1 2. (Currently Amended) The method as recited in claim 1, wherein determining the
2 model comprises determining the model for a single-phase liquid producing well.
- 1 3. (Currently Amended) The method as recited in claim 1, wherein determining the
2 model comprises determining the model for a multi-layer producing well.
- 1 4. (Currently Amended) The method recited in claim 1, wherein determining the
2 model comprises determining the model for a multi-layer, single-phase liquid producing
3 well.
- 1 5. (Currently Amended) The method as recited in claim 1, wherein determining the
2 model comprises determining the model for a multi-layer, multi-phase liquid producing
3 well.
- 1 6. (Currently Amended) The method as recited in claim 1, wherein measuring the
2 temperatures comprises measuring temperature with a distributed temperature sensor.

- 1 7. (Currently Amended) The method as recited in claim 1, wherein the inverting
2 comprises determining a degree of certainty in the production rates allocated.
- 1 8. (Currently Amended) The method as recited in claim 7, wherein determining the
2 degree of certainty comprises determining a degree of error in the model, the method
3 further comprising compensating for the determined degree of error in the model in
4 performing the inverting.
- 1 9. (Currently Amended) The method as recited in claim 7, wherein determining the
2 degree of certainty comprises determining a degree of error in the measured
3 temperatures, the method further comprising compensating for the determined degree of
4 error in the measured temperatures in performing the inverting.
- 1 10. (Currently Amended) The method as recited in claim 7, wherein determining the
2 degree of certainty comprises determining a degree of error in well parameter values, the
3 method further comprising compensating for the determined degree of error in the well
4 parameter values in performing the inverting.
- 1 11. (Currently Amended) The method as recited in claim 1, wherein inverting using
2 the optimization algorithm comprises utilizing a generalized reduced gradient
3 optimization algorithm.

- 1 12. (Currently Amended) A method of determining flow rates in a well, comprising:
2 measuring ~~temperature~~temperatures at a plurality of points along the well having
3 a plurality of well zones and a plurality of liquid phases;[[and]]
4 measuring a total flow rate from the well; and
5 determining, by a computer, flow rates of the plurality of liquid phases through
6 each of the plurality of well zones via the measured temperatures, wherein the
7 determining comprises inverting the measured temperatures by applying a model,
8 wherein the inverting comprises allocating by the total flow rate among the plurality of
9 well zones.
- 1 13. (Currently Amended) The method as recited in claim 12, wherein measuring the
2 temperature at the plurality of points comprises utilizing a distributed temperature sensor.
- 1 14. (Currently Amended) The method as recited in claim 12, wherein determining the
2 flow rates comprises constructing [[a]]the model of temperature as a function of zonal
3 flow rates in the well, and using the model to invert the measured temperatures in
4 allocating the flow rates from the plurality of well zones based on the measured total flow
5 rate.
- 1 15. (Currently Amended) The method as recited in claim 12, wherein determining the
2 flow rates comprises determining flow rates of oil and water phases during production.
- 1 16. (Currently Amended) The method as recited in claim 12, wherein determining the
2 flow rates comprises determining flow rates of fluid injected into each of the plurality of
3 well zones.
- 1 17. (Currently Amended) The method as recited in claim 14, wherein inverting the
2 measured temperatures comprises utilizing an optimization algorithm that solves an
3 optimization problem for calculating the flow rates, where the optimization problem
4 minimizes an error between the measured temperatures and corresponding temperatures
5 calculated by the model.

1 18. (Cancelled)

1 19. (Currently Amended) A system, comprising:

2 a temperature sensor deployable with a production completion along a wellbore to
3 sense temperature data at a plurality of wellbore locations during production; and

4 a processor system configured to receive the sensed temperature data and
5 allocate flow rates from a plurality of wellbore zones based on the sensed
6 temperature data, wherein the processor system is configured to allocate the flow rates by
7 inverting the sensed temperature data using a temperature forward model, wherein the
8 inverting comprises using an optimization algorithm that solves an optimization problem
9 for calculating the flow rates, where the optimization problem minimizes an error
10 between the sensed temperature data and corresponding calculated temperature data from
11 the model.

1 20. (Currently Amended) The system as recited in claim 19, wherein the ~~processor~~
2 ~~system uses a~~ temperature forward model specifies, in which temperature [[is]] as a
3 function of zonal flow rates, ~~to invert the temperature data and allocate flow rates from~~
4 ~~producing layers of a formation.~~

1 21. (Original) The system as recited in claim 19, wherein the temperature sensor
2 comprises a distributed temperature sensor.

1 22. (Currently Amended) The system as recited in claim 19, wherein the processor
2 system is able configured to allocate flow rates in a multi-layer, multi-phase liquid
3 producing well.

1 23. (Original) The system as recited in claim 19, wherein the production completion
2 comprises an electric submersible pumping system.

1 24. (Original) The system as recited in claim 19, wherein the production completion
2 comprises a gas lift system.

1 25. (Original) The system as recited in claim 19, wherein the wellbore is oriented
2 generally vertically.

1 26. (Currently Amended) A method, comprising:
2 deploying a distributed temperature sensor along a wellbore;
3 utilizing a model of temperature as a function of fluid flow rates ~~into~~in the
4 wellbore;
5 obtaining ~~temperature data~~measured temperatures from the distributed
6 temperature ~~system~~sensor;
7 ~~allocating~~determining fluid flow ~~rate~~rates in corresponding ~~in at least one~~
8 wellbore ~~zone~~zones using the ~~temperature data~~measured temperatures in conjunction
9 with the model, ~~wherein the determined fluid flow rates are calculated using an~~
10 optimization algorithm that solves an optimization problem, where the optimization
11 problem minimizes an error between the measured temperatures and corresponding
12 temperatures calculated by the model; ~~and~~
13 ~~determining error in the fluid flow rate.~~

1 27. (Currently Amended) The method as recited in claim 26, wherein ~~allocating~~
2 determining the fluid flow rates comprises inverting the ~~temperature data~~measured
3 temperatures using the model to obtain the fluid flow ~~rate~~rates.

1 28. (Currently Amended) The method as recited in claim 26, wherein deploying the
2 distributed temperature sensor comprises deploying the distributed temperature
3 ~~system~~sensor in a generally vertical wellbore.

1 29. (Currently Amended) The method as recited in claim 26, wherein deploying the
2 distributed temperature sensor comprises deploying the distributed temperature
3 ~~system~~sensor in a deviated wellbore.

- 1 30. (Cancelled)
- 1 31. (Currently Amended) The method as recited in claim 26, wherein
2 ~~allocating~~determining the fluid flow rates comprises determining flow rates for a single-
3 phase liquid producing well.
- 1 32. (Currently Amended) The method as recited in claim 26, wherein
2 ~~allocating~~determining the fluid flow rates comprises determining flow rates for a multi-
3 phase liquid producing well.
- 1 33. (Currently Amended) The method as recited in claim 26, ~~wherein determining~~
2 ~~comprises compensating for further comprising:~~
3 determining a model error, a measurement error, and a well parameter error; and
4 compensating for the model error, measurement error, and well parameter error
5 when inverting using the model to determine the fluid flow rates.
- 1 34.-36. (Cancelled)
- 1 37. (New) The method as recited in claim 1, further comprising:
2 measuring a total flow rate of the well at a wellhead; and
3 allocating, by the model, the total flow rate among the different producing zones
4 based on the measured temperatures.
- 1 38. (New) The system as recited in claim 19, further comprising:
2 a sensor to measure a total flow rate of the wellbore at a wellhead,
3 wherein the processor system is configured to allocate, using the model, the total
4 flow rate among the plurality of wellbore zones based on the sensed temperature data to
5 allocate the flow rates.